Legacy Roads and Trails Monitoring Project Update 2012

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In 2008, Congress created the Legacy Roads and Trails program to fund US Forest Service (USFS) projects focused on reducing the impacts of roads and trails on water and aquatic resources. The Rocky Mountain Research Station partnered with the Pacific Northwest, Intermountain, Northern and Pacific Southwest Regions of the USFS to assess the effectiveness of road storm damage risk reduction (SDRR), decommissioning , and storage treatments in reducing the runoff and erosion impacts of forest roads on streams.

We assess the effectiveness of treatments for reducing: 1) road-stream hydrologic connectivity; 2) fine sediment production and delivery; 3) mass wasting; and 4) stream crossing failure risk. We carefully inventory roads before and after treatments, focusing on the condition of the road drainage system. We use the GRAIP model to predict improvements in outcomes based on implemented treatments. Ultimately we return to the roads to observe the response of treated vs. untreated control roads to large storms. Data collection has been initiated at 47 sites (Figure 1). Detailed post-treatment data analysis and reporting has been completed for 11 treated sites. Similar analysis and reporting has been completed for four sites subjected to large storms. These reports are posted at the GRAIP website as they are completed and reviewed (http://www.fs.fed.us/GRAIP/case_studies.shtml).

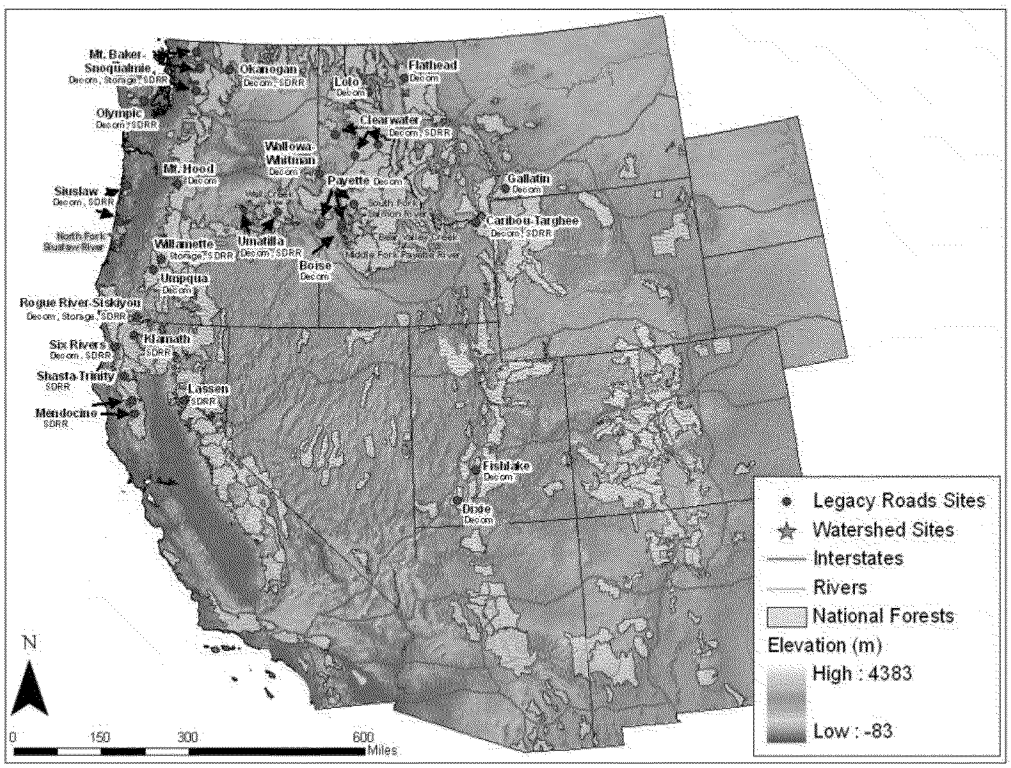

Figure 1: Map of Legacy Roads and Trails Monitoring Project sites

The GRAIP methodology uses a GPS-based road inventory combined with a GIS-model to characterize the hydrologic and sedimentation impacts and risks of a road. The sediment model uses a base erosion rate modified by observed length, slope, road surfacing and vegetation cover to predict erosion from the road and the observed road to stream hydrologic connectivity to predict the sediment delivery. The base erosion rate for the study sites was kept constant between sites to investigate the changes solely due to treatments.

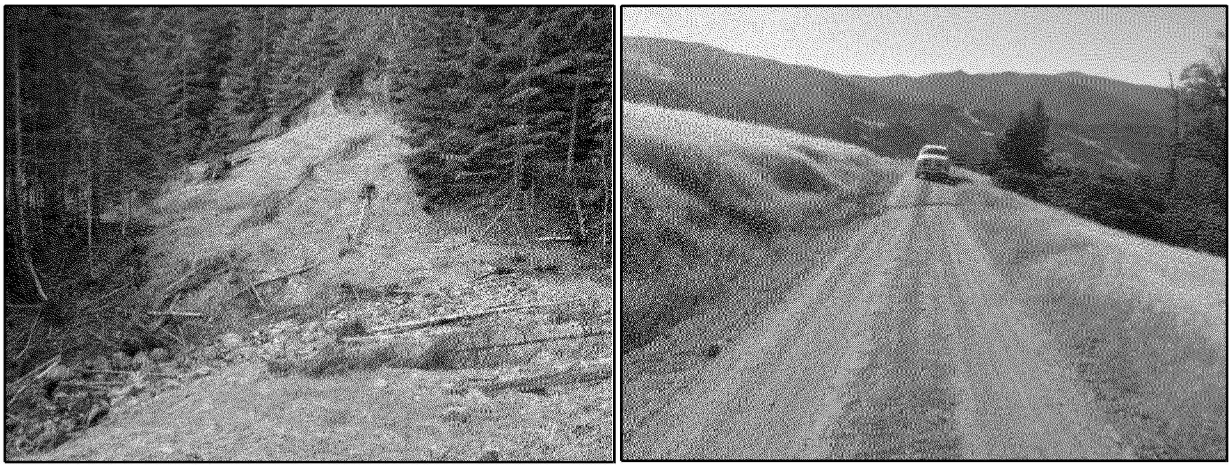

Figure 2: A recontoured road and excavated stream crossing on a decommissioned road and a broad-based dip used as part of an SDRR treatment.

Road decommissioning, SDRR (Figure 2) and storage are the categories of road treatment being monitored. Decommissioning treatments included both full and partial recontouring of the road prism and intensive restoration of stream crossings. SDRR included lower cost treatments that were applied extensively across the road system. The most common treatments included increased drainage frequency and capacity, road surfacing improvements and stream crossing failure risk reduction measures. Storage treatments typically included increased drainage frequency, modification of drainage structures and the prevention of vehicle access. Data analysis is currently underway and results are available for 25 of the monitored sites.

Hydrologic Connectivity

Roads can intercept shallow groundwater and convert it to surface runoff, resulting in local hydrologic impacts when that water is discharged directly to channels (Wemple et al., 1996). Additional runoff is also produced from the compacted road surface. Basin-scale studies in the Oregon Cascades suggest that a high degree of integration between the road drainage system and the channel network can increase some peak flows (Jones and Grant, 1996).

Road decommissioning was monitored at 11 sites with 67.7 km of total road before treatments were applied. Decommissioning the road prism reduced road-stream hydrologic connectivity by 9.8 km and reduced the connected fraction by 58% (Table 1). SDRR treatments were monitored at 12 sites with 86.3 km of road in the pre-treatment sample. The SDRR treatments reduced stream connectivity by 2.3 km and reduced the fraction connected by 9%.

Post-storm inventories on untreated control roads for 9 road decommissioning projects indicate a substantial increase in connectivity between pre-treatment and post-storm of 4.2 km (33%) while the treated sites showed a substantial decrease of 6.9 km (-44%) of connected road. Post-storm inventories of 4 untreated control roads at SDRR sites showed much smaller changes. Control road connectivity increased by 0.2 km (+3%) and treated roads increased by 1.1 km (+11%).

Table 1. Changes in the properties of roads due to road decommissioning and storm damage risk reduction treatments. One Mg of sediment is 1,000 Kg.

Initial Treatment Effects		
	Decommissioned Roads n=11 segments, 67.7 km	**SDRR Roads n=12 segments, 86.3 km**
Road-Stream Hydrologic Connectivity	**-9.8 km**, reduced from 16.9 to 7.1 km (**-58%**)	**-2.3 km**, reduced from 24.9 to 22.6 km (**-9%**)
Fine Sediment Delivery	**-119 Mg/yr**, reduced from 187 to 67 Mg/yr (**-64%**)	**-119 Mg/yr**, reduced from 235 to 116 Mg/yr (**-51%**)
Drainpoint Problem Rate	Reduced from 22% to 3% (**-86%**)	Reduced from 25% to 14% (**-48%**)
Unit Sediment Delivery	**-1.8 Mg/yr/km**, reduced from 2.8 to 1.0 Mg/yr/km (**-64%**)	**-1.4 Mg/yr/km**, reduced from 2.7 to 1.3 Mg/yr/km (**-51%**)

Table 2. Changes in the properties of treated and control roads as differences between pre-treatment and post storm inventories.

Post-Storm Validation				
	Decommissioned Roads, n=9		**SDRR Roads, n=4**	
	Treated, 60.5 km	**Control, 58.2 km**	**Treated, 26.4 km**	**Control, 25.0 km**
Road-Stream Hydrologic Connectivity	**-6.9 km,** reduced from 15.8 to 8.9 km (**-44%**)	**+4.2 km**, increased from 12.9 to 17.0 km (**+33%**)	**+1.1 km**, increased from 9.8 to 10.9 km (**+11%**)	**+0.2 km**, Increased from 7.5 km to 7.7 km (**+3%**)
Fine Sediment Delivery	**-194 Mg/yr**, reduced from 244 to 50 Mg/yr (**-80%**)	**+89 Mg/yr**, increased from 105 to 204 Mg/yr (**+94%**)	**-80Mg/yr**, reduced from 119 to 39 Mg/yr (**-67%**)	**No Change**, from 28 to 28 Mg/yr (**0%**)
Drainpoint Problem Rate	Reduced from 21% to 13% (**-38%**)	Increased from 16% to 24% (**+50%**)	Reduced from 24% to 15% (**-38%**)	**-1%**, decreased from 25% to 24% (**-4%**)
Unit Sediment Delivery	**-3.3 Mg/yr/km**, reduced from 4.1 to 0.8 Mg/yr/km (**-80%**)	**+1.7 Mg/yr/km**, increased from 1.8 to 3.5 Mg/yr/km (**+94%**)	**-3.0 Mg/yr/km**, reduced from 4.5 to 1.5 Mg/yr/km (**-67%**)	**No Change**, 1.3 Mg/yr/km (**0%**)

Sediment Production

Fine sediment production for a road segment (E) is estimated based on a base erosion rate and the properties of the road (Luce and Black, 1999), as shown below.

E [redacted]

B is the base erosion rate[1] (kg/m)
L is the road length (m) contributing to the drain point
S is the slope of the road segment discharging to the drain point (m/m)
V is the vegetation cover factor for the flow path
R is the road surfacing factor

Sediment Delivery

Sediment delivery from large studies of forest roads has been found to be localized at a small fraction of the drain points. Delivery of eroded sediment to the channel network is determined by observations of each place that water leaves the road. Each of these drain points is classified as delivering, not delivering, or uncertain. No estimate of fractional delivery is made because there is insignificant hillslope sediment storage in locations where there is a clear connection to the channel under most circumstances. For this analysis, uncertain observations were treated as delivering.

On 67.7 km of decommissioned roads, post-treatment inventories indicated a cumulative decrease of 119 Mg/yr which is a 64% reduction in the sediment delivery. Post-storm inventories indicate an even larger reduction from the pre-treatment conditions with a net reduction of 194 Mg/yr or an 80% reduction in delivery. Post-storm inventories of the control roads indicate a cumulative increase in delivery of 89 Mg/yr (94%) following the storm event (Table 2).

On 86.3 km of SDRR roads, post-treatment inventories indicate a cumulative reduction of 119 Mg/yr or a 51% reduction in the sediment delivery. Post-storm inventories indicate a net reduction of 80 Mg/yr or a 67% reduction in delivery. SDRR control roads show no change in delivery.

Changes in sediment delivery can be driven by changes in connection and/or changes in sediment production. Decommissioned roads show the largest decreases in sediment delivery because both connection and sediment production are reduced. The control roads for the decommissioning study show increased delivery largely due to a small increase in connected road length. As connected road length does not change much on the SDRR roads, the decrease found on these roads is largely due a reduction in sediment production.

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[1] For this analysis, a base erosion rate of 79 kg/m of road elevation was assumed, based on observations in the Oregon Coast Range (Luce and Black 1999). Further work could determine if this rate is appropriate for this climate, geology, and road system. This study is concerned with the effects of the applied treatments; hence the relative change, not the absolute numbers, is the primary concern.

The decommissioning treatments resulted in the greatest reductions in unit sediment delivery. The sediment delivery rate at the post-treatment sites was 1.0 Mg/yr/km for the decommissioning treatments and 1.3 Mg/yr/km for the SDRR treatments. During the post-storm sampling the sediment delivery rate was 0.8 Mg/yr/km for the decommissioned sites and 1.3 Mg/yr/km for the SDRR sites. Decommissioning treatments achieved larger reductions because the intensity of the treatments was greater than the intensity of the SDRR treatments; however, the more intense decommissioning treatments cost more per kilometer than the lower intensity SDRR treatments.

Drain Point Condition

The condition of drain points was assessed during the GRAIP inventory to determine how well each feature was performing its intended function. Problems with drain point condition are pre-defined for each drain type. For example culverts are defined to have poor condition if they have more than 20% occlusion of the inlet by sediment, substantial inlet crushing, significant rust or flow that goes around or below the pipe. Poor drain point condition was observed at 22% of the decommissioning pre-treatment sites and 3% of the post treatment sites. The SDRR roads had poor drain point condition at 25% of the pre-treatment and 14% of the post-treatment sites. Post-storm inventories on decommissioned sites located poor drain point condition at 21% of the pre-treatment sites and 13% of the post-storm sites. The control roads increased from 16% with poor drain point condition to 24% in the post-storm inventory. The SDRR treated roads had a decrease in the rate of poor condition from 24% in the pre-treatment to 15% in the post-storm while the control roads showed a decrease from 25% to 24%.

Forthcoming Results

The pre and post-treatment GRAIP road inventory data have been collected at nearly all the 47 sites as of September 2012, although many sites have not had a post-storm inventory yet. Once the analysis of sediment production, sediment delivery and hydrologic connectivity are completed, the analysis of landslide risk, gully risk, stream crossing plugging and stream crossing diversion potential will begin.

Summary

The treatments that have been monitored to date indicate that the decommissioning treatments applied to existing roads provided large reductions in sediment delivery and hydrologic connectivity even after substantial rainfall events resulted in significant impacts from similar roads. SDRR treatments produced more modest reductions in sediment delivery and hydrologic connection. Road decommissioning reduced the unit length delivery of surface derived fine sediment to the lowest overall rate.

This document will be updated as more results become available. Please visit the GRAIP website at: http://www.fs.fed.us/GRAIP/index.shtml to obtain more detailed reports on many of the projects summarized here.

Contact Tom Black (tblack@fs.fed.us) or Nathan Nelson (nnelson@fs.fed.us) for additional information on GRAIP or the Legacy Roads and Trails Monitoring Project.